INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0475

Swing-Reduced Crane Control

Deactivation and Decommissioning
Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

August 1999

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Summary Report

Swing-Reduced Crane Control

OST Reference #1815

Deactivation and Decommissioning
Focus Area

Demonstrated at
Argonne National Laboratory-East
Argonne, Illinois

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Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://OST.em.doe.gov under "Publications."

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SECTION 1

SUMMARY

Technology Description

This report presents an evaluation of a swing-reduced crane control system that is designed to minimize the swinging induced in loads being moved by a crane and to enhance the operator's ability to control the remote positioning of loads. The evaluation is based largely on the performance of the system as part of the Large-Scale Demonstration Project (LSDP) held at the Chicago Pile-5 Research Reactor (CP-5) located at Argonne National Laboratory-East (ANL-E). The LSDP is sponsored by the U.S. Department of Energy (DOE), Office of Science and Technology, Deactivation and Decommissioning Focus Area (DDFA). The objective of the LSDP is to demonstrate innovative technologies or technology applications potentially beneficial to the decontamination and decommissioning of contaminated facilities.

The Department of Energy (DOE), Office of Technology Development (OTD), Robotics Technology Development Program (RTDP) through the Oak Ridge National Laboratory (ORNL) and the Savannah River Technology Center (SRTC) has provided the technology necessary for this demonstration. The technology employs a No-Sway™ crane controller manufactured by Convolve Inc. as shown in Figure 1 along with newly developed AC motors known as AC flux vector control motors, or more commonly, vector drives. Vector drives use a closed-loop control scheme to adjust the voltage frequency and phase and the current frequency and phase that are applied to a three-phase induction motor. These motors allow the programmable logic controller (PLC) to control the motor speed and acceleration. The No-Sway™ crane controller uses a solid state PLC to control the motion of the crane bridge or trolley in order to minimizes the amount that a load will swing when it is being moved by a crane and to permit a crane operator to move the crane in precise steps without causing the swinging of the load.

The installation of the swing reducing controller was part of a larger effort to upgrade the CP-5 facility crane. In addition to the new controller, the crane was fitted with a motorized rotating hook and a camera with pan, tilt and zoom capabilities. The original control pendant was replaced by a new pendent designed to be use only for off-normal operations. A new radio frequency remote control unit was added as the primary operator station. New cables were installed on both hooks and the brakes and transmissions were all inspected, adjusted and tested. All of the costs for the complete crane upgrade are provide in this document although only the new swing reducing technology is discussed in detail.

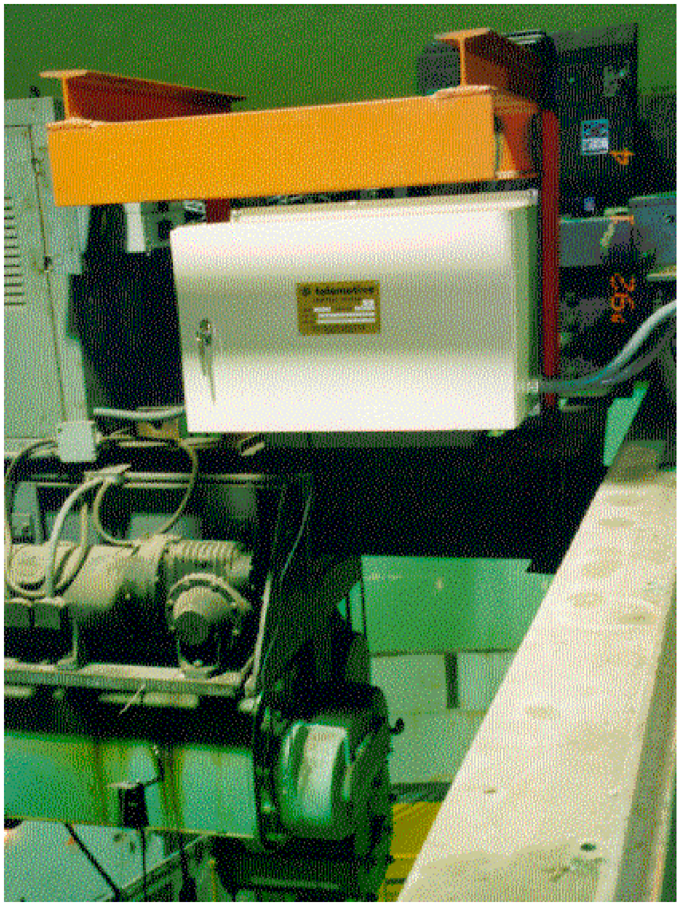

Figure 1. Programmable Logic Controller (PLC) mounted on the CP-5 Crane

Technology Status

Swing-reduced crane technology has been demonstrated at ORNL, SRTC, Sandia National Laboratory (SNL) and now at ANL-E. A passive swing-reducing system called No-Sway™ is currently being marketed by Convolve, Inc. This system utilizes a patented technology referred to as Input Shaping™. A working agreement exists between Convolve, Inc., the designer and manufacturer of the No-Sway™ crane controller and Whiting Services, Inc., a crane repair, maintenance and inspection company. At the present time there are no commercial cranes equipped with swing-reducing crane controllers, however, several utility companies have shown a very strong interest in this technology.

Work at ORNL and SNL continues on the more sophisticated active systems. Less expensive and more robust transducers are being developed along with more accurate control algorithms. It appears that it will be difficult to retrofit older cranes with the equipment necessary for active control however it should be relatively simple to design new cranes with all of the necessary hardware. This same technology should be able to be applied to other systems such as robotics to minimize vibrations or oscillations so that accurate remote positioning can be achieved in the shortest possible time.

The installation of the swing-reduced crane technology at the CP-5 reactor facility has been very successful. The system has been in place for just over one year and has worked flawlessly except for a few minor shakedown problems immediately after the installation. The crane has been remotely operated almost every workday over the last year moving waste containers and positioning robotics equipment. During that time it has also been used to make several "engineered lifts" that exceeded the normal operating capacity of the crane.

Key Results

The key results of the demonstration are as follows:

- Swing-reducing technology can be applied to older cranes.
- Swing-reducing technology can be applied to polar cranes.
- Passive swing-reducing crane controllers are commercially available.
- Experienced commercial crane maintenance companies are available to install the hardware necessary for swing-reduced operation.
- Passive swing-reducing technology can reduce the swing time by 60% or more.
- Operators can quickly learn to use the system.
- The step mode is very useful when an operator has to accurately position a load from a remote location.

Contacts

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Licensing Information

No licensing or permitting activities were required to support this demonstration.

Web Site

The CP-5 LSDP Internet address is http://www.strategic-alliance.org.

SECTION 2

TECHNOLOGY DESCRIPTION

System Configuration and Operation

The CP-5 facility was built in 1954 with a polar crane having a 21m (70ft) bridge that spans the containment building and runs on a circular track 9m (30ft) above the main floor. The trolley that travels across this bridge is equipped with both a 20-ton hoist and a 5-ton hoist. Until the facility ceased operation in 1979, the crane was operated from a standard crane pendent. The crane was unused from that time until the decontamination and decommissioning (D&D) activities began in 1989. Prior to making any critical lifts as part of the D&D operations, the crane was thoroughly inspected, overhauled and certified. The D&D activities were going to require the movement of a large amount of radioactive material. In order to minimize the exposure to workers, the crane was modified so that it could be operated remotely using a Telemotive Series 8000 radio control system rather than the pendent.

Another modification that was made at this time was that the 5-ton hoist was fitted with a powered rotating hook manufactured by PaR Systems Corporation. This hook, shown in Figure 2, provided a great deal of versatility in moving waste containers and positioning robotics equipment.

Figure 2. Electrically powered 5-ton rotating hook

In order for the operator located in a remote location to be able to accurately determine the position of the load, an Elbex security camera was installed on the bottom of the trolley. This color video camera is equipped with pan tilt and zoom capabilities and has proven very useful in providing surveillance of the entire containment area.

When a load is lifted and moved by a crane it is free to swing like a pendulum. This is normally not much of a problem because it takes relatively little force to damp out this swinging and an operator can usually stabilize the load by hand. In remote operation, however, this is not possible and the swinging motion makes the accurate positioning of loads very difficult and time consuming. There is the potential for damaging either the load or other equipment in the area. The operator must move the load very slowly to minimize the induced swinging and allow time for the oscillations to damp out before proceeding to the next operation.

A skilled operator, through proper techniques, can minimize the amount a load will swing. For example, as the trolley starts forward the load, because of its inertia, will tend to remain stationary as shown by the dotted configuration in Figure 3.

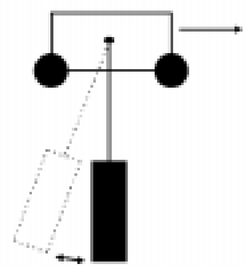

Figure 3. Moving trolley with a suspended load

If the crane operator momentarily stops the trolley and waits for the load to swing forward, he can again start the trolley moving at the same speed as the load at the moment that the load is directly under the trolley. The trolley and the load will then continue to move along at the same constant velocity until another acceleration or deceleration is applied to the trolley. This same technique can be used to minimize swaying when the trolley is stopped. In this case the load will continue to travel forward after the trolley is stopped. At the precise moment that the velocity of the load becomes zero before it reverses direction the operator must step the trolley forward so that it is positioned directly over the load. These maneuvers depend on both the skill of the operator and on the speed and acceleration of the crane.

Swing-reducing control systems use this same technique to minimize the induced swinging, however, they use a programmable logic controller (PLC) rather than the skill of the operator to control the trolley position. There are two different control methods that are currently being developed. The sensor-based, or active, control system is the most sophisticated and the most costly approach. It relies on some type of transducer or sensor monitoring the location of the load relative to the trolley and feeding this information back to a computer and the PLC that controls the speed and acceleration of the trolley. The model-based, or passive, control system is much simpler and much less expensive. It relies on knowing the frequency of the pendulum system which is a function of only the pendulum length. The pendulum length can either be measured with a transducer or an average length can be assumed. This system has the disadvantage that, if a load is picked up off-center and begins swinging or if the load bumps something and begins swing, the model-based system will not try to stop the oscillations.

For either of these two systems to operate effectively the speed and acceleration of the trolley and /or bridge must be accurately controlled. Most industrial cranes, and the crane at CP-5, have AC induction motors. These motors are inherently simpler, more reliable and easier to repair than DC motors but they will only operate well at one or possibly two speeds. Over the past several years an improved AC motor, identified as an AC flux vector control motor or vector drive, has been developed. These new AC motors permit both the speed and the acceleration to be adjusted over a wide range.

A model-based No-Sway™ (see Figure 1) designed and fabricated by Convolve was installed on the CP-5 crane by Whiting Services Inc. This controller is equipped with a switch that allows the operator to select an assumed pendulum length for either a high load or a low load. The speed and acceleration of both the trolley and the bridge are simultaneously controlled. This is the first time that this type of controller has been installed on a polar crane. The Convolve system uses a standard input-shaping Allen Bradley PLC. In addition, the CP-5 bridge and trolley drive motors were replaced with Baldor Vector Drives.

A very useful feature that Convolve built into the control system for the CP-5 crane is the ability to make single or multiple step movements with the crane. It is very difficult, if not impossible, for a crane operator to remotely move a load close to a fixed object without actually hitting it. This type of move can easily be done using the CP-5 crane in the step mode. The controller is set in the step mode and a second selector switch is set in position 1, 2 or 3. This determines the size of the step that will be taken by the crane - 0.5 in., 1.5 in. or 4 in., respectively. Then, each time the drive switch on the control panel is bumped, the load will step forward the specified amount with no swinging or overshoot. This is extremely useful when trying to accurately position loads in a crowded environment.

SECTION 3

PERFORMANCE

Swing-reduced Crane Control System Performance

After the CP-5 crane modifications were complete and the operators had been instructed on the operation of the No-Sway™ system and the remote controller, a series of performance checks was made to ensure that the system met all of its contractual requirements. Specifically, the speeds of the bridge and trolley were to remain within 20% of the original speeds and the system was required to reduce the time necessary for the swinging to damp out by at least 60%. These measurements were made with a tape measure and a stopwatch and are probably no more than 10% accurate. From the data presented in this table, it is clear that the crane speeds were changed by less than 10% in all cases.

Table 1. Pre and Post Installation Speed Tests

Direction	Distance	Shaper	Time (sec)	Speed	% Change From Original
Pre Installation Speed Tests			8/29/96		
Bridge CW	180 deg		123.0	1.46 deg/sec	
Trolley Out	84 in		16.9	4.97 in/sec	
Trolley In	84 in		16.4	5.12 in/sec	
Post Installation Speed Tests			10/3/96		
Bridge CW	180 deg	Off	125.0	1.44 deg/sec	-1.4
Trolley Out	84 in	Off	17.6	4.77 in/sec	-4.0
Trolley In	84 in	Off	18.2	4.62 in/sec	-9.8
Bridge CW	180 deg	On-Low	126.0	1.43 deg/sec	-2.1
Trolley Out	84 in	On-Low	17.8	4.72 in/sec	-5.0
Trolley In	84 in	On-Low	17.7	4.75 in/sec	-7.2

Notes:
1) Had crane at full speed before start of timing
2) Bridge rotation CW when looking up from floor
3) Speeds required to be within +/- 20%

Table 2 presents the data that was collected to verify that the amount of time required for the swing to damp out was reduced at least 60% by the crane modifications. This table presents data for the crane hook at two different locations, a low position eighteen inches above the floor and a high position about fifteen feet above the floor. It should be noted that were are significant differences between the times recorded before the crane modifications and the times recorded after the modifications but with the input shaper turned off. Some of the difference noted are due to the fact that new drive motors were installed but since the carriage and trolley speeds only changed slightly, it is believed that the major cause of these time differences is the new cables that were installed. It is not obvious way some of the times increased and some of them decreased. What is clear from this table is that, when the shaper was turned on, the time it took for the load to stop swinging was greatly reduced. The swinging was considered stopped when the swing was less than one inch. These criteria tended to distort the results so that cases that had short swing times with the controller off could not show much improvement. It would have been more meaningful if the time required to damp the swing 80% or some other fixed percentage had been used. The system showed at least a 60% reduction in the tine required for the oscillations to damp out over the original system and at least a 50% improvement was achieved simply by turning on the shaper.

Table 2. Pre and Post Installation Swing Time Tests

Pre Installation Swing Time Tests		8/29/96	Post Installation Swing Time Tests		10/3/96			
Direction	Hook Position	Time (sec)	Shaper	Time (sec)	Shaper	Time (sec)	% Change From Original	% Change From Shaper Off
Trolley Out	18" high	40.0	Off	23.7	On-Low	5.6	86.0	76.4
Trolley In	18" high	32.0	Off	37.6	On-Low	6.2	80.6	83.5
	18" high, 11.5' out	17.0	Off	23.0	On-Low	5.7	66.5	75.2
Bridge CCW	18" high, 11.5' out	16.0	Off	42.6	On-Low	6.1	61.9	85.7
Trolley In, Bridge CW	18" high	24.0	Off	54.3	On-Low	6.6	72.5	87.8
Trolley Out, Bridge CCW	18" high	21.0	Off	53.5	On-Low	7.8	62.9	85.4
Trolley Out	Hook at line	17.0	Off	12.3	On-High	5.0	70.6	59.3
Trolley In	Hook at line	19.0	Off	13.2	On-High	6.1	67.9	53.8
Bridge CW	Hook at line, ~15' out	17.0	Off	24.0	On-High	6.6	61.2	72.5
Bridge CCW	Hook at line, ~15' out	21.0	Off	19.9	On-High	7.6	63.8	61.8
Trolley In, Bridge CW	Hook at line	27.0	Off	24.0	On-High	6.3	76.7	73.8
Trolley Out, Bridge CCW	Hook at line	30.0	Off	16.8	On-High	5.3	82.3	68.5

Notes:
1) Hook height measured from floor to bottom of hook. Distance out equals hook centerline to reactor.
2) Started timer when pendant button was released, and stopped when total hook swing was less than 1".
3) Bridge CW when looking up at crane.
4) 20 Ton hook used for swing tests
5) Hook at line means the bottom of the hook is approximately at the line of white and green paint on wall. This is approximately 15 feet high where the catwalk attached to the wall.
6) Must reduce swing time by 60% or more to be accepted.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

Technology Applicability

The swing-reduced crane control technology is applicable to a wide range of cranes and gantries. It can be either built into new systems or retrofitted onto older systems. The basic technology, however, has much broader applicability. It can be used on robotics arms or through-the-wall manipulators to enhance the operator's ability to control these systems. It could also be applied to machine tools, either manually controlled or numerically controlled. In short, it could be employed on any system that has to accelerate or decelerate and is expected to be accurately positioned.

Competing Technologies

The baseline technology with which the swing-reduced technology competes is standard on-off operation using conventional AC induction motors that has been the norm for more than seventy-five years.

Patents/Commercialization Sponsor

No issues related to patents, commercialization, or sponsorship are pending.

SECTION 5

COST

Introduction

While the cost of modifying the CP-5 crane was quite high, the swing-reducing controller and the new motors were only a fraction of the overall costs and resulted in increased reliability. The new cables, the remote video, the rotating hook and the remote radio controller were all modifications that were not required for swing-reduced operation.

Evaluating the cost savings which result from swing-reduced operation is very difficult. Not every lift benefits from swing-reduced operation. If a load can be picked up from one location and moved to another location and there is nothing in the way that the load can hit and the load swinging does not cause a problem the new system has no advantage. In addition, an extremely talented crane operator may be able to make the crane operate almost as well without the swing-reducing controller. Finally, how does one evaluate the reduced possibility of either damaging the load or other equipment in the area. A swing-reduced system may be used in an area where there is non-replaceable, one-of-a-kind pieces of equipment. Not being able to accurately predict the amount of time that a swing-reducing system will save or the amount of damage that it will prevent makes it very difficult to access it true worth.

The Swing Free Crane provides limited cost savings for the work applications typical of CP-5. Improvements in safety are the principal reasons for the purchase of this technology. It is anticipated that movement of loads using this technology will result in reductions in transport time. But, in the normal D&D work for CP-5, the use of the crane is intermittent and there will not be a measurable accumulation of savings. In other applications, where the use of the crane is intensive and repetitive, there may be substantial savings because of improvements in productivity. The purpose of this analysis is to establish the total costs (vendor and support required by site) for not only acquiring this technology but also for making the other crane upgrades.

Methodology

This analysis covers the innovative technology for a crane swing control system, remote video camera, radio controlled remote operation, powered rotating crane block, and load cells with digital readout . The Swing Free Crane technology was demonstrated at an ANL site under controlled conditions which facilitated observation of the work procedures. The analysis is based on costs for a non-typical installation at CP-5. They are quoted as being at the maximum expected cost by the vendor.

The standard operating system (baseline) was not demonstrated for a comparison as each site is expected to have it’s own unique material handling requirements. It is also noted that some labor, equipment and materials were provided by site personnel at ANL.

The selected basic activities being analyzed come from the Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS), USACE, 1996. The HTRW RA WBS, developed by an interagency group, is used in this analysis to provide consistency with the established national standards.

Some break-out of costs are omitted from this analysis as the Vendor considers the information to be proprietary. The ANL direct expense rates for common support and materials are added where required to give an more accurate account to this analysis. Overhead and General and Administrative (G&A) rates are not included since the rate for each DOE site may vary in magnitude and in the way they are applied. However, an amount of 9.3% has been added to the cost for procurement (standard rate for ANL). Decision makers seeking site specific costs can apply their site’s rates to this analysis where appropriate. Quoted rates for the vendor’s costs are used in this analysis and include the vendor’s G&A overhead and other mark ups.

Summary of Cost Variable Conditions

The cost for the Swing Free Technology depends principally upon the type of crane being modified and the crane's controller system. Additionally, the conditions under which the modification is being made will affect cost. Table 3 summarizes the conditions for installation at CP-5.

Table 3. Summary of Demonstration Conditions

Cost variable	Swing Free Technology
Scope of Work	
Quantity & Type of Material	Bridge Crane **(20 ton)**
Location	Crane spanning reactor core.
Work Environment During Modification	
Level of contamination	Not a factor in work
Temporary protection	No protective equipment worn
Work Performance for Modification of Crane	
Acquisition Means	Vendor provided service
End Condition	Anti-sway installed and remote operation capable

Cost Conclusions

The baseline technology is a standard crane configuration. The Swing Free crane technology may provide an increase in crane productivity (the vendor claims as much as 25%) under some conditions. However, for the type of work applications at CP-5, there would not be significant production gains and therefor no large cost savings. The size of crane will affect the number of motors required and the type of crane control system will affect the way in which the interface between the crane and anti-swing equipment is constructed. This technology may also require the vendor to design the interfacing. Therefore, off-the-shelf purchase of equipment would not be feasible at this time. Total cost (including ANL support) for materials and installation of swing free, camera and remote control by a vendor is estimated to be $ 299,031. A table of the costs for mobilization, characterization, and demobilization for the new technology can be seen in Appendix C.

SECTION 6

REGULATORY/POLICY ISSUES

Regulatory Considerations

The regulatory/permitting issues related to the use of the swing-reduced crane control technology at the ANL CP-5 Test Reactor are governed by the following DOE Orders and safety and health regulations:

- American Society of Mechanical Engineers
  —ASME B30.2d-1994 Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings - Overhead and Gantry Cranes

Safety, Risks, Benefits, and Community Reaction

The swing-reduced crane controller technology is generally quite safe to operate. Identified hazards are those typical of working in industrial situations with electrical powered instrumentation. Physical hazards from working in confined or elevated tight spaces associated with maintenance of the systems are also present.

The use of the swing-reduced crane controller technology rather than the baseline technology would have little impact on community safety, environmental, or socioeconomic issues. Any such impacts would be mostly favorable relative to the baseline technology.

SECTION 7

LESSONS LEARNED

Implementation Considerations

- The step mode can be very useful in accurately positioning loads.
- Both operators and supervisors, particularly those with many years of experience, do not perfer to use this new technology. They find it disturbing to take their finger off the control button and still hear the trolley or bridge motor running even if the load is perfectly stationary. Perhaps more operator training is required.
- During the installation and setup a decision must be made as to what are the most desirable step sizes for the step mode.
- Delivery time for powered, rotating hooks were in excess of one year. The reason for the long delivery time is not known.

Technology Limitations

- If a load is swinging because it was picked up off center or because it bumped something this system can not be used to stop the swinging. The way the system is currently configured, the operator would have to turn off the swing-reducing controller and manually bump the control button or paddle to stop the oscillations. The controller could be turned back on and the load moved.
- The technology is not well suited for work in the exact center of a polar crane.

Technology Selection Considerations

- This technology should be considered before the purchase of any new crane.
- Because of the cost of replacing the drive motors, only cranes that are use for critical application should be retrofitted for swing-reduced operation.
- A remote camera located on the trolley is extremely useful.

Appendix A

REFERENCES

Kress,R.L., Noakes,M.W., Jansen,J.F., and Toy,H., “Swing-Free Technical Information," Oak Ridge National Laboratory, ORNL/M-3698, August 1994.

Occupational Safety and Health Administration, (OSHA) 29 CFR 1910, *Occupational Safety and Health Standards*, 1974.

Occupational Safety and Health Administration, (OSHA) 29 CFR 1926, *Occupational Safety Regulation for Construction*, 1979.

Appendix B

ACRONYMS AND ABBREVIATIONS

AC	alternating current
ACE	Activity Cost Estimates (sheets)
ANL-E	Argonne National Laboratory-East
CCWC	counterclockwise
CW	clockwise
P-5	Chicago Pile-5 Research Reactor Facility
DC	direct current
D&D	decontamination and decommissioning
DOE	U.S. Department Of Energy
FCCM	Facilities Capital Cost Of Money
FETC	Federal Energy Technology Center
G&A	General and Administrative
HRS	hours
HTRW	Hazardous, Toxic, Radioactive Waste
LS	Lump Sum
LSDP	Large Scale Demonstration Project
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OTD	Office of Technology Development
PLC	programmable logic controller
PLF	Productivity Loss Factor
RA	Remedial Action
RTDP	Robotics Technology Development Program
SNL	Sandia National Laboratory
SRTC	Savannah River Technical Center
TC	Total Cost
TQ	Total Quantity
UC	Unit Cost
USACE	U.S. Army Corps Of Engineers
WBS	Work Breakdown Structure
WPI	Waste Policy Institute

Appendix C

TECHNOLOGY COST ESTIMATE

This appendix contains definitions of cost elements, descriptions of assumptions, and computations of unit costs that are used in the cost analysis.

Innovative Technology - Swing Free

MOBILIZATION (WBS 331.01)

Swing Free Control
Definition: Packaging and shipping of Swing Free components to Argonne from Tucker Georgia.. Cost breakout provided by Whitning Services Inc.

Camera, Radio Control, Precise Load Measuring, Remote Digital Readout:
Definition: Packaging and shipping of remote control related components.

D&D (WBS 331.17)

Swing-Free Control
Design Modifications
Definition: Design engineering required for assembly and fabrication of controller system.. Cost breakout provided by Whitning Services Inc.

Shop Assembly:
Definition: Vendor shop work to assemble motor controller system.

Components/Materials
Definition: Materials and components used in fabrication/assembly of motor controller system.

Field Installation
Definition: Vendor field personnel install swing free equipment**.**

Start-Up and Testing
Definition: Vendor field personnel check out system following installation**.**

ANL Site Support
Definition: ANL personnel support for installation of swing free equipment. Includes oversight (safety engineering and construction field representative for 15 hours), machine shop (modify brackets for the motor mounts for 6 hours of support) and HPT support (specifically for survey of the crane).

Camera, Remote Digital Readout, Radio Control & Load Measuring System

Design Modifications
Definition: Design engineering required for assembly and fabrication of the remote control system.. Cost breakout provided by Whitning Services Inc.

Components/Materials
Definition: Materials and components used in fabrication/assembly of the remote control system.

Shop Assembly:
Definition: Vendor shop work to assemble/fabricate system.

Field Installation
Definition: Vendor field personnel install swing free equipment**..**

Start-Up and Testing
Definition: Vendor field personnel check out system following installation**.**

ANL Site Support
Definition: ANL personnel support for installation of remote control system. Includes machine shop (36 hours to modify remote block and fabricate camera mount) and electrician for electrical panel installation and camera installation.

Rotating Block
Definition: This activity provides for purchase of a new rotating block. The demonstration used a block borrowed from Oak Ridge National Laboratory which was rated at 5-tons. Since borrowing the small block was a temporary means of avoiding delaying the demonstration (while waiting for the powered block that is really required), this cost analysis uses the cost of a new 10-ton block.

ANL Site Escorts
Definition: ANL personnel escort vendor field personnel during installation of the swing free and the remote control equipment (235 hours).

DEMOBILIZATION (WBS 331.21)

Swing Free Control
Definition: Vendor costs for cleaning up the work area, packaging up equipment used to install the swing free system, and return to the vendor's office.

Camera, Radio Control, Precise Load Measuring, remote digital readout
Definition: Vendor costs for cleaning up the work area, packaging up equipment used to install the swing free system, and return to the vendor's office.

Procurement Cost

Definition: ANL costs for award and administration of contract for fabrication and installation service (9.3% of contract amount).

Table C-1 Costs for Swing Free and Remote Control System

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor HRS	Labor Rate	Equipment HRS	Equipment Rate	Other	Total UC	Total Quantity (TQ)	Unit of Measure	Total Cost (TC) note	Comments
MOBILIZATION WBS 331.01										
Swing Free Control	0.00	$ -	0.00	$ -	$ 15,000	$ 15,000	1	Each	$ 15,000	
Cam.,Remote & Other	0.00	$ -	0.00	$ -	$ 18,000	$ 18,000	1	Each	$ 18,000	
								Subtotal	**$ 33,000**	
D&D WBS 331.17										
PROCUREMENT OF EQUIPMENT WBS 331.17.03										
Swing-Free Control										
Design Modifications	0.0000	$ -	0.0000	$ -	$ 22,000	$ 22,000	1	Each	$ 22,000	
Shop Assembly	0.0000	$ -	0.0000	$ -	$ 12,000	$ 12,000	1	Each	$ 12,000	
Components/Materials	0.0000	$ -	0.0000	$ -	$ 38,000	$ 38,000	1	Each	$ 38,000	
Field Installation	0.0000	$ -	0.0000	$ -	$ 10,000	$ 10,000	1	Each	$ 10,000	
Start-up & Testing	0.0000	$ -	0.0000	$ -	$ 5,000	$ 5,000	1	Each	$ 5,000	
ANL Site Support	0.0000	$ -	0.0000	$ -	$ 2,593	$ 2,593	1	Each	$ 2,593	
Camera, Remote Digital										
Readout, Radio Control &										
Load Measuring System										
Design Modifications	0.00	$ -	0.00	$ -	$ 17,000	$ 17,000	1	Each	$ 17,000	
Components/Materials	0.00	$ -	0.00	$ -	$ 49,000	$ 49,000	1	Each	$ 49,000	*<< A camera price of
Shop Assembly	0.00	$ -	0.00	$ -	$ 7,000	$ 7,000	1	Each	$ 7,000	$13,000.00 is included*
Field Installation	0.00	$ -	0.00	$ -	$ 9,000	$ 9,000	1	Each	$ 9,000	
Start-up & Testing	0.00	$ -	0.00	$ -	$ 5,000	$ 5,000	1	Each	$ 5,000	
ANL Site Support	0.00	$ -	0.00	$ -	$ 3,175	$ 3,175	1	Each	$ 3,175	
Rotating Block	0.00	$ -	0.00	$ -	$ 46,000	$ 46,000	1	Each	$ 46,000	*<< Cost of a new Block *
ANL Site Escorts	235.00	$ 33.60	0.00	$ -	$ -	$ 7,896	1	Each	$ 7,896	
								Subtotal	**$ 233,664**	
Work Breakdown Structure (WBS)	**Unit Cost (UC)** Labor HRS	Rate	Equipment HRS	Rate	Other	Total UC	**Total Quantity (TQ)**	**Unit of Measure**	**Total Cost (TC)** note	**Comments**
DEMOBILIZATION WBS 331.21										
Swing Free Control	0.00	$ -	0.00	$ -	$ 5,000	$ 5,000	1	Each	$ 5,000	
Cam.,Remote & Other	0.00	$ -	0.00	$ -	$ 7,000	$ 7,000	1	Each	$ 7,000	
								Subtotal	**$ 12,000**	
PROCUREMENT COST										
ANL Procurement Cost						$ 20,367	1	Each	$ 20,367	Cost for procurement is 9.3% (standard rate for ANL)
								Subtotal	**$ 20,367**	
								TOTAL:	**$299,031**	

Note: TC = UC * TQ